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ELEVATOR TENSION MEMBER ASSEMBLY TECHNIQUES

1. Field of the Invention.

This invention generally relates to elevator tension members such as those used in belts or ropes. More particularly, this invention relates to handling and arranging tension member components within an assembly.

2. Description of the Related Art.

Elevator systems often include a car and counterweight supported by a rope or belt. Conventional machines move the rope or belt to cause the desired movement of the car between levels within a building, for example. Traditionally, steel ropes were used. More recently, flat belt technology has been introduced. The flat belts provide traction and bending fatigue resistance advantages.

One example flat belt arrangement includes a plurality of steel tension members encased in a polyurethane jacket. The steel tension members may include a plurality of wires that are wound together to form cords, which serve as the tension members. It is possible for one or more wires to break at different times during the assembly process. A broken wire end that becomes entangled in the assembly machinery during the winding process or later when the jacket is applied to the tension members can cause a problem such as damage to the machinery or at least significantly interrupting production.

Similar problems exist in jacketed round rope manufacturing. There is a need for techniques to manage such broken wires.

If the stock were simply cut at the point of each break, the length of stock would be randomly and undesirably limited. Most elevator installations require lengthy, uninterrupted tension member.

One proposed arrangement has been to cut an entire strand or cord (i.e., all of the constituent wires) at the point of the wire break and then to weld together the two cut ends. This proposal provides significant shortcomings. The breaking strength and bending fatigue resistance required for tension members in an elevator belt are

significantly compromised when the cut-and-weld technique is employed. In some circumstances, the service life based on bending fatigue is reduced by more than 50%.

This invention provides alternatives for handling situations where one or more wires are broken during an elevator tension member or belt or rope assembly process.

SUMMARY OF THE INVENTION

In general terms, this invention is a technique for effectively managing broken wires during an elevator tension member or rope or belt assembly process.

One example method of making an elevator tension member includes arranging a plurality of wires into at least one strand. A plurality of strands are then arranged into at least one cord. The method includes determining if there is at least one broken wire end protruding from at least one of the strands or at least one of the cords while performing the corresponding arranging steps. If there is at least one broken wire, the ends of the wire are manipulated to prevent them from protruding away from the corresponding strand or cord.

In one example, any detected broken wire ends are inserted into the corresponding strand or cord. In one example, the broken ends are twisted around at least one adjacent unbroken wire. In another example, the broken ends are weaved among unbroken wires.

In another example, the broken wire ends are secured against an outer surface of the corresponding strand or cord. In one example, the broken wire ends are welded or brazed in place. In another example, the broken wire ends are adhesively secured in place.

The various features and advantages of this invention will become apparent to those skilled in the art from the following detailed description of the currently preferred embodiments. The drawings that accompany the detailed description can be briefly described as follows.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1A schematically shows a portion of an elevator belt assembly.

Figure 1B schematically shows an end of a jacketed rope assembly.

Figure 2 schematically illustrates a belt assembly process.

Figure 3A and 3B schematically illustrate, in somewhat more detail, the belt assembly process, highlighting a situation where one or more broken wires exist.

Figure 4 is a schematic illustration of method of making a belt assembly designed according to an embodiment of this invention.

Figure 5 schematically illustrates an example tool for performing a method of this invention.

Figure 6 schematically illustrates a preferred feature of the example tool also shown in Figure 5.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 1A schematically shows a portion of an elevator belt 20. A plurality of tension members 22 are encased in a polyurethane jacket 24. In one example, the tension members 22 are cords that comprise seven strands, which each comprise seven individual wires. The wires are wound in a known manner to form strands and the strands are wound in a known manner to form the cords. In the illustrated example there are twelve tension members 22 (i.e., twelve cords). In another example, there are eight tension members across the width of the belt 20.

Figure 1B shows an end of a jacketed rope 25 having a plurality of tension members 26 made much like the tension members 22 of the example in Figure 1A. A polyurethane jacket 28 surrounds the tension members 26, which are wound together as a rope.

Figure 2 schematically illustrates an assembly process 30 where wire stock 32 of individual wires is provided to a cord winding machine 34 that first winds a plurality of wires into individual strands and then winds a plurality of strands into a cord. The completed cords are placed on spools and eventually provided to a jacket application machine 36 where the cords are appropriately positioned and placed within the jacket 24 or 28 to form the belt or rope eventually sent to appropriate storage 38. Known techniques can be used for each of the stages schematically shown in Figure 2.

Referring to Figures 3A and 3B, a plurality of wires 40 from the wire stock 32 are twisted in a known manner to establish a strand 42. In this example, seven individual wires 40 are within each individual strand 42. As shown in Figure 3A, one

of the wires 40 has a broken section with two ends 44 protruding away from the exterior of the strand 42. This condition is detected by a detector 50, which can be a known device as used in high speed winding machinery, for example. Once the broken ends 44 are detected, the winding machinery preferably is shut down so that the condition of the broken wire can be addressed. If the winding process continued, the broken wire would likely become entangled in the machinery causing significant problems and machine down time.

In this example, the broken ends 44 shown in Figure 3A are recaptured as part of the strand 42 in a manner that the broken ends do not protrude away from the strand such that there is any risk of entanglement with the belt manufacturing machinery. In one example, the broken ends 44 are manipulated manually and inserted in between other ones of the wires 40 in the area of the broken ends. Other example techniques include weaving the broken portions of the wires within the strand or twisting them around at least one adjacent unbroken wire. By tucking in the broken ends, they are effectively captured within the strand in a manner that they will not protrude out and cause difficulties for the machinery.

In another example, the broken wire ends are manipulated and placed against the strand. An adhesive is applied to the strands 42 in the vicinity of the broken ends 44 such that the broken ends are secured in position as part of the strand and they do not protrude outward. In still another example, the ends 44 are welded or brazed in place against adjacent wires at the appropriate location along the strand. Any brazing or welding material preferably is kept from protruding in a manner that may interfere with the manufacturing process.

Another example includes welding or brazing the broken ends of a wire together.

In another example, the portion of a wire that protrudes outward is cut off so that the remaining portions are flush with the rest of the strand.

Once the winding machinery stops upon detection of a broken wire, the tension on the wires is relaxed so that manual manipulation of the broken wire ends 44 is possible to achieve the recapture of the broken ends using a chosen technique.

Figure 3B schematically illustrates a later portion of the process where the individual strands 42 are wound together to form a cord 46. As shown in the example

of Figure 3B, another detector 52 inspects the cords for broken wires protruding away from the exterior of the cord, for example. In the illustration, broken wire ends 54 are detected and the machinery is stopped so that the broken wire ends can be recaptured into the cord. Any one of the example techniques described above are used in this stage of the process to again ensure no entanglements during later processing of the cords to form the elevator belt 20 or rope 25. The detector 52 comprises known detecting components.

Once a cord has passed inspection by the detector 52, it can be provided to a jacket application machine including an extruder, for example, for applying the polyurethane jacket 24 or 28 to establish the belt or rope configuration.

Figure 4 schematically illustrates a method of making one example belt assembly 20. In this example, the jacket is extruded over the cords such that the jacket exterior is smooth, continuous and not interrupted by any grooves. A cord supply 50 provides the cords 46. In one example, the cord supply 50 comprises a plurality of spools containing the wound steel wire strands that form the cords 46. The cords may be formed at the same facility as where the method of applying the jacket 24 is accomplished or the cords may be preformed and prespooled, depending on the needs of a particular situation.

A positioning device 52 aligns the cords 46 in a desired alignment so that the cords will extend parallel to a longitudinal axis of the belt assembly 20. A tensioning device 54 controls an amount of tension on the cords 46 during the jacket application process. Although a single tension station 54 is schematically illustrated, multiple tension devices may be used along the assembly line of the belt assembly 20. For example, the same tension preferably is applied to the cords on both sides of the jacket application station 56. The tension station 54 preferably includes a suitably programmed controller that monitors and controls the tension within a desired range.

More particularly, the tension on each individual cord preferably is maintained at a desired level throughout the process of making the belt assembly so that the belt configuration or geometry is controlled as much as possible. The tension on each individual cord may be different with respect to the other cords. In one example, a base tension of approximately 50 Newtons is placed on each cord and a sample belt assembly is made. The sample belt assembly preferably then is inspected to make

sure that the geometry is as desired. If there are undesirable variations, such as a slight longitudinal curvature, the tension on one or more individual cords is adjusted to address the undesirable belt geometry variation. By making several samples and taking measurements and making adjustments, the necessary individual cord tensions to yield the desired belt geometry can be determined.

The tension on each individual cord preferably is significant enough so that the cord horizontal position remains the same throughout the jacket application process. Because this example includes eliminating cord supports in the jacket application portion of the manufacturing process, the tensions used during the example process may need to be higher than those that were used in supported cord techniques.

Although not specifically illustrated, tension feedback devices (as known in the art) preferably are incorporated into the manufacturing equipment so that the tension on each individual cord can be monitored and adjusted as needed throughout the entire assembly process.

The jacket application station 56 preferably includes a suitable mold or other device for applying the jacket material onto the cords 46. A supply 58 provides the chosen material to the jacket application station 56 in a conventional manner. The jacket material may be pressure molded, extruded or otherwise applied to the cords 46.

In one example, rollers 59 are included as part of or immediately after the jacket application station 56. The rollers 59 preferably are Teflon coated. The rollers 59 provide a surface treatment to the sheave-contacting surfaces of the belt assembly immediately after the application of the jacket material. In this example, the rollers provide smooth, flat, parallel belt surfaces. The rollers 59 may provide an embossed pattern on the jacket surfaces, for example. The rollers 59 preferably are included because the elimination of the cord supports as used in conventional equipment introduces a need for additional dimensional control. The rollers 59 provide such additional dimensional control.

In the illustrated example, the rollers 59 are positioned on opposite sides of the belt assembly (although only one roller is visible in the illustration of Figure 4). The

rollers 59 preferably extend across the entire width of the belt assembly for best dimensional control of the belt surfaces.

In one example, the rollers 59 are freewheeling and move responsive to movement of the belt assembly as it passes through the rollers. In another example, the rollers are motorized so that they move at a controlled rate.

The formed belt assembly 20 is then processed at a finishing station 60. In one example, the finishing station 60 includes a forming device, a dimensional inspection device and a curing cold water bath where the jacket material and the cords within the material are cooled to a suitable temperature.

The inspection device, such as a known laser triangulation measuring device, determines whether the desired geometry was achieved.

The resulting belt assembly 40 preferably is then stored at 62, for example on spools for shipment to various locations for installation in elevator systems. The belt assembly 20 may be precut to specific lengths or may be provided in larger quantities where a technician at the installation selects the appropriate amount of belt material for a particular application.

Figure 5 schematically illustrates an example molding device 70 for applying the jacket 24 to the cords 46. Conventional arrangements include a plurality of cord supports, which cause the formation of grooves in at least one exterior surface on the belt assembly 20. Because this invention includes eliminating such grooves, a typical cord supporting arrangement having such cord supports preferably is not used.

The example forming device 70 of Figure 5 includes a mold housing 72 having an input side 74. A cord positioning device 76 preferably is situated at the input side 74. The cord positioning device 76 includes a plurality of openings 78 through which the cords 46 are fed into the device 70. The openings 78 preferably are accurately machined or otherwise formed so that a close tolerance is kept between the exterior of the cords 46 and the interior of the opening 78. Having a tight fitting between the openings 78 and the cords 46 prevents backflow of the jacket material during the molding process.

As can be appreciated from Figure 5, for example, as the cords 46 pass through the openings 78 in the cord positioning device 76, any stray, broken wire ends

might not get past the openings 78. This could cause distortion of the cords and interrupt the belt manufacturing process.

In one example, the condition of the cords is inspected as part of the jacket application process to prevent any difficulties that might otherwise occur because of stray wire ends. Another detector like those described above may be associated with the forming device 70 at appropriate locations to ensure appropriate wire placement during the belt manufacturing process.

The mold housing 72 includes one or more openings 79 through which the jacket material is applied to the cords using pressure injection. As known in the art, pressure injection can be used for molding materials such as polyurethane when the material is suitably heated. Given this description, those skilled in the art will be able to select appropriate conditions for achieving a desired result.

The molding device 70 includes an opening 80 at an output side 82 of the mold housing 72. The opening 80 preferably is shaped to control the exterior shape and surfaces on the belt assembly 20.

The opening 80 of the molding device 70 in the example of Figure 6 has a non-linear configuration along the portions of the opening that form the sheave-contacting belt surfaces. The non-linear configuration provides for differences in the thickness of the belt assembly as seen across the width. As can be appreciated from the illustration, the portions of the belt assembly corresponding to the locations of the cords 46 have a reduced thickness compared to the portions of the belt assembly where no cords are present.

The varying, non-linear configuration of the surfaces 86 and 88 are designed to accommodate the variation in the amount of shrinkage across the width of the belt that will occur during the finishing and curing of the belt assembly. It is believed that the amount of shrinkage corresponds to the cross section of urethane jacket material. In the areas where the cords 46 are present, there will be less shrinkage because of the presence of the cord material, which in some examples is steel. The portions of the belt assembly where cords are not present has a temporary greater thickness because there will be more shrinkage at those points of the assembly.

Providing a variation in the thickness across the width of the assembly facilities achieving a final resulting flat, parallel alignment between the surfaces 86

and 88. The type of configuration illustrated in Figure 6 is unique to the example approach to manufacturing a belt assembly. In prior processes, mold wheels were included as part of the jacket application station. Such mold wheels operated to compress the jacket material into more of a flat configuration as part of the initial cooling process. Therefore, the non-linear, varying thickness approach, which is part of one example implementation of this invention, addresses the varying amounts of shrinkage that occur during a curing process in a unique manner.

In one example, there is approximately a .05 to .10 millimeter variation in the thickness of the jacket provided by the opening 80 of the molding device illustrated in Figure 6. The overall dimensions of a particular belt assembly, the dimensions of the cords and the chosen jacket material will dictate the particular thickness variation required for a particular situation. Given this description, those skilled in the art will be able to select appropriate dimensions to meet the needs of their particular situation.

With this invention, the length of belt or rope stock and cord stock is significantly enhanced. If the sections of strand or cord were simply cut each time a wire was broken, there would be an undesirable amount of material scrap and many potentially unuseful lengths for most elevator installations. Using the example techniques described above provides for significant enhancement of the length of cord and belt stock. In one example, the length of belt without any cut-and-weld joints in the tension members can be on the order of 13 km. Accordingly, the example techniques make the tension member manufacturing process far more economical and efficient.

The example embodiments may include one or more broken wires at some point. In examples where seven wires form each strand and seven strands form each cord, one broken wire presents approximately a 2% loss of continuous wire tension-bearing capability. This minor difference does not appreciably affect strength because so many of the wires are intact and there are a plurality of cords, some or a majority of which may have no wire breaks at all.

With the example techniques, broken wires are manageable in a manner that increases manufacturing efficiency and the economies associated with making and installing elevator belts and ropes.

The preceding description is exemplary rather than limiting in nature. Variations and modifications to the disclosed examples may become apparent to those skilled in the art that do not necessarily depart from the essence of this invention. The scope of legal protection given to this invention can only be determined by studying the following claims.